ERD11 PROGRESS REPORT

RICH simulations

LAPPD tests

Hubert van Hecke
On behalf of the ERD11 collaboration

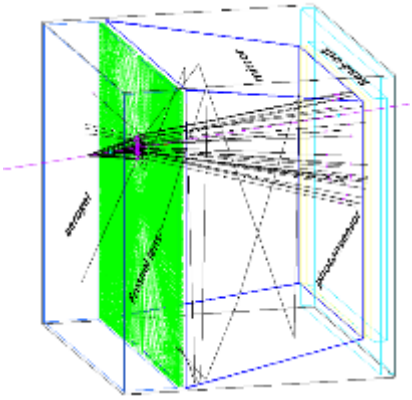
Los Alamos NATIONAL LABORATORY EST. 1943

ERD11 collaboration

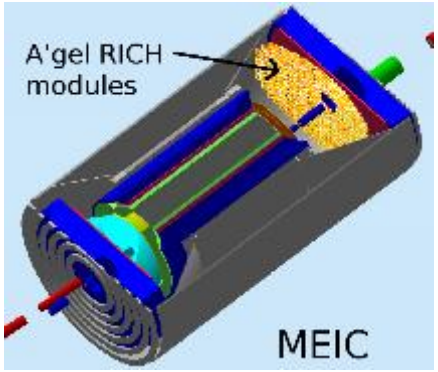
Fernando Barbosa, William Brooks, Marco Contalbrigo, Amaresh Datta, Marcel Demarteau, J. Matthew Durham, Douglas Fields, Xiaochun He, Hubert van Hecke (co-PI), Jin Huang, Ming Liu, Jack McKisson, Rodrigo Mendez, Yi Qiang, Patrizia Rossi, Murad Sarsour, Robert Wagner, Jingbo Wang, Cheuk-Ping Wong, Wenze Xi, Liang Xue, Beni Zihlmann, Zhiwen Zhao, Carl Zorn

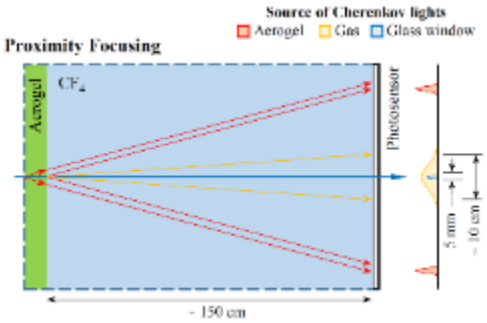
Simulation overview

- Done
- On-going
- Plan



- Implement detector options in standalone mode
  - Modular aerogel imager
    - Lens focusing, a novel design
    - Proximity focusing (base design BELL II forward ARICH)
  - Dual-radiator designs
    - Proximity focused
    - Mirror focused (base design LHCb RICH)
- Generic analysis packages
  - Ring finder/fitter
  - Tracking + RICH likelihood based analyzer
- Geant4 simulation and analysis in full EIC environment
  - Realistic Spectrum, multiplicity, and detector backgrounds
  - In reference to designs of MEIC concept, BeAST, ePHENIX, eSTAR





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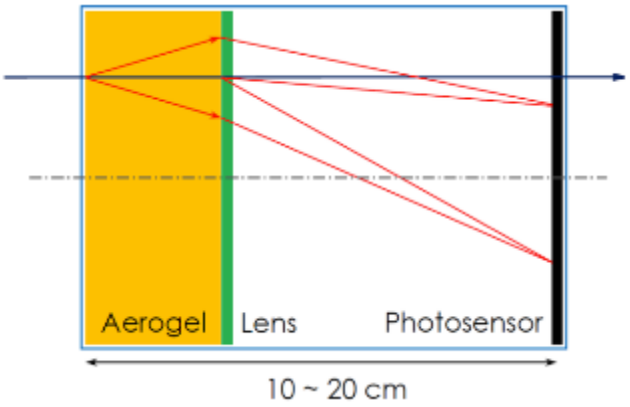
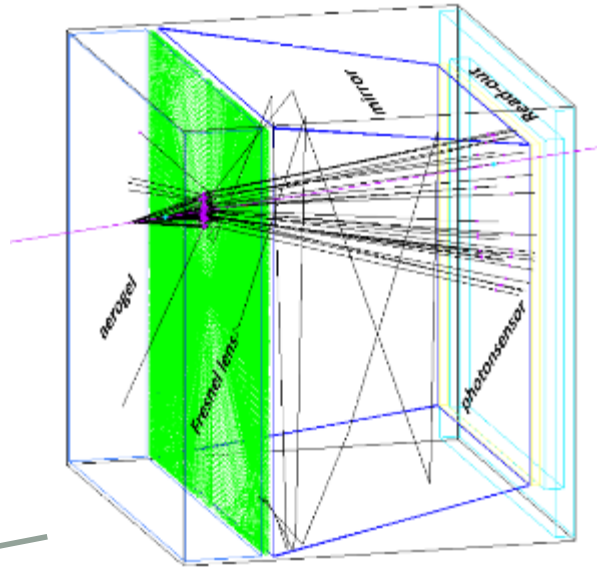
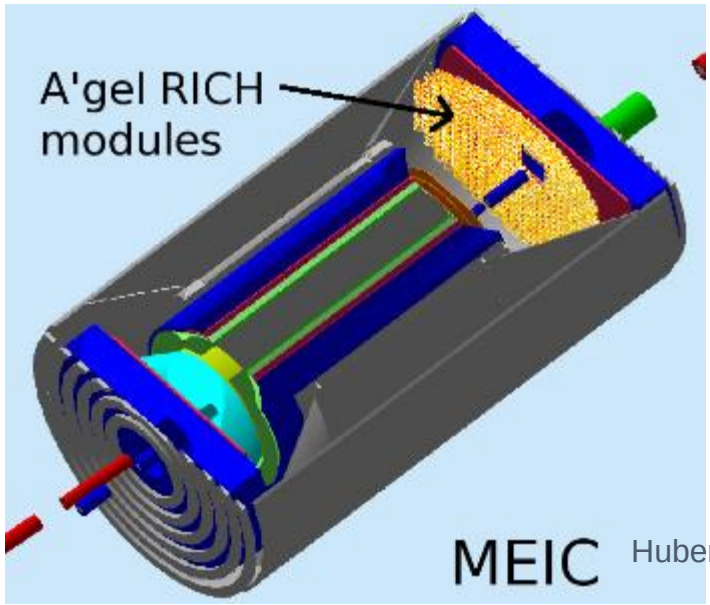
Modular RICH simulations - concept to Geant4 to full detector implementation



Implemented in Geant4
(see prog. rep. Jan 2015)





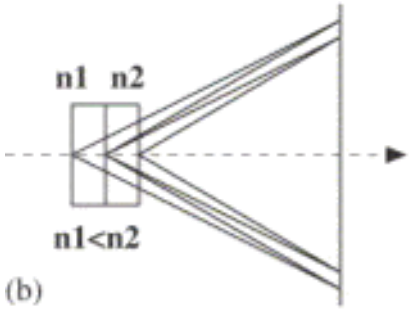
And integrated into an EIC detector
(new)

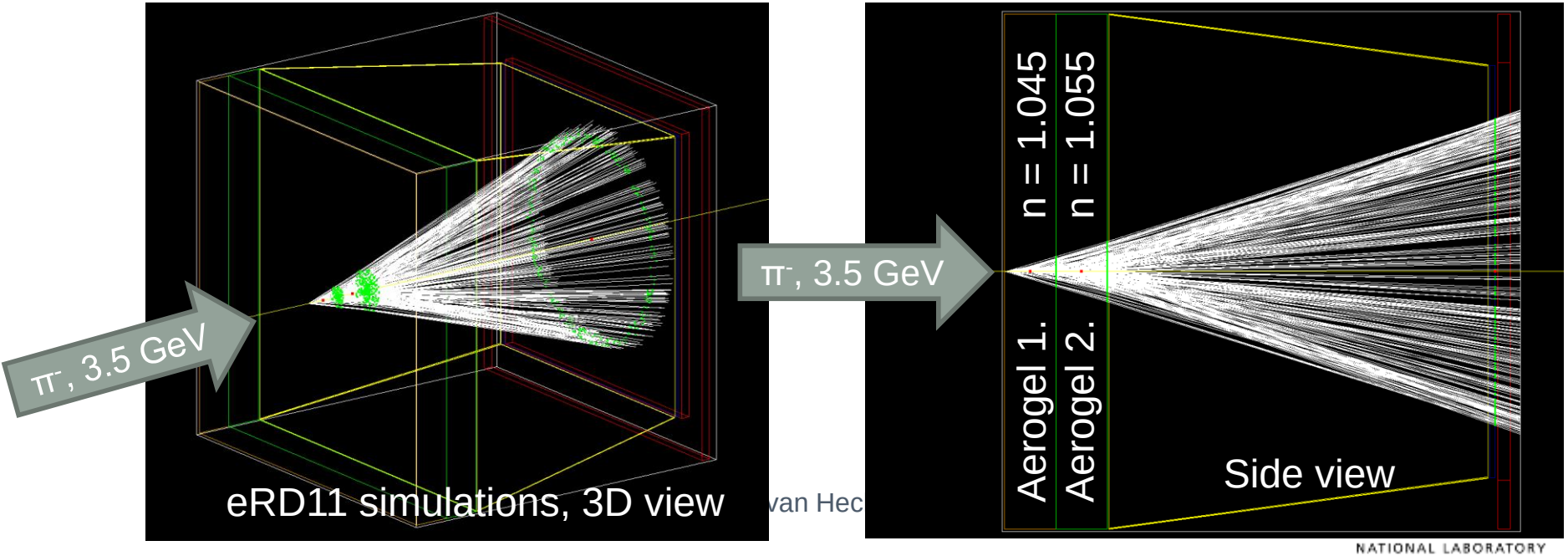
Modular RICH simulations - study of the approximate focusing RICH

Work done by Liang Xue (GSU), funded under eRD11

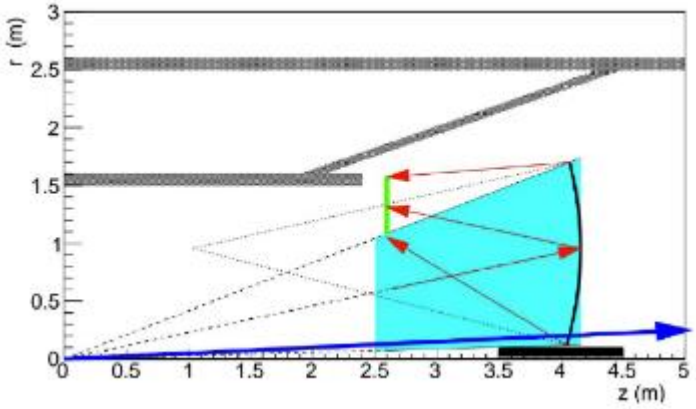
- Following suggestions from last meeting, we have been broadening our design options
- One example is the approximate focusing RICH, Design based on BELL II forward ARICH concept
- Easily implemented based upon our simulation/analysis framework
- To be quantified in full EIC detector in the next stage

Base design: BELL II ARICH
NIM. A548 (2005) 383-390
PoS TIPP2014 (2014) 123





Dual radiator RICH simulations (propose to get further funded) Systematic conceptual study started

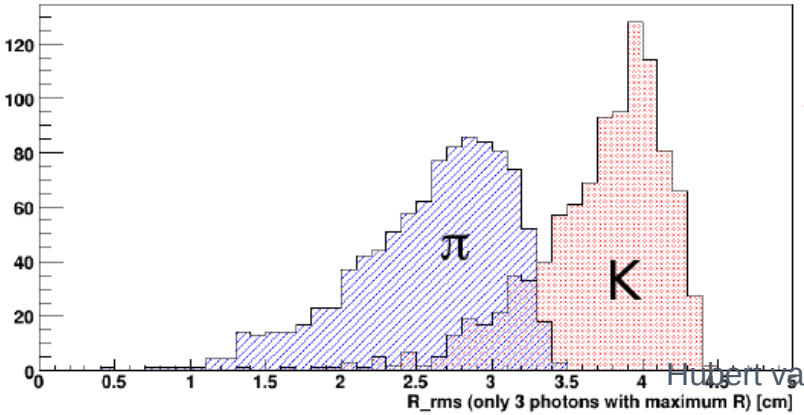


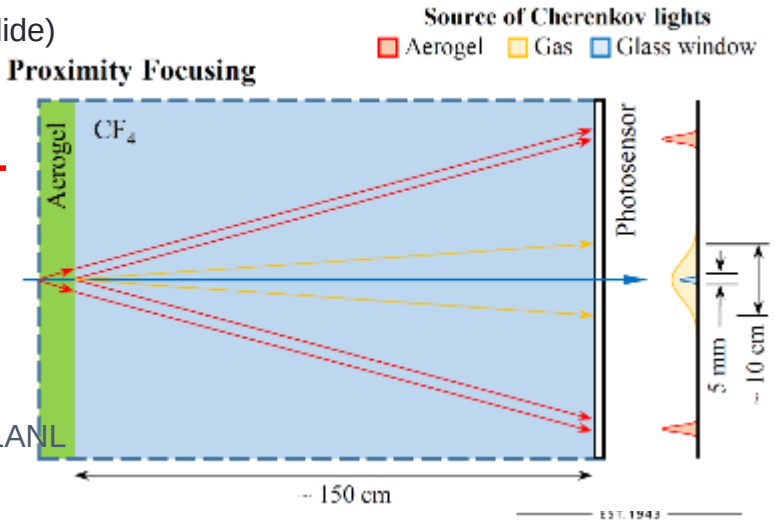
Recently initiated under eRD11 with Jlab-INFN funding by Dr. Alessio Deldotto (INFN)
Propose to ramp up effort under PID consortium funding

- Concept design and PID efficiency for proximity focusing RICH
- Concept design and PID efficiency for mirror focused RICH
- Implementation in Geant4 simulation and interface to our analysis package
- Performance quantification in full EIC detector simulation

- On-going
- Plan

Differentiation power for the (non focused) gas radiator (Aerogel see next slide)



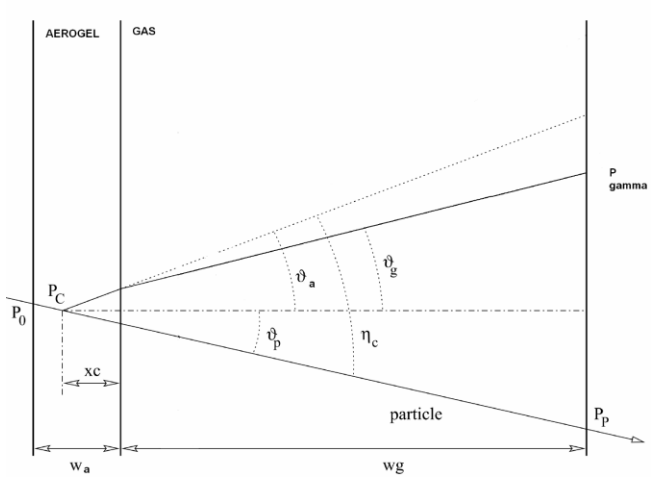


Dual radiator RICH

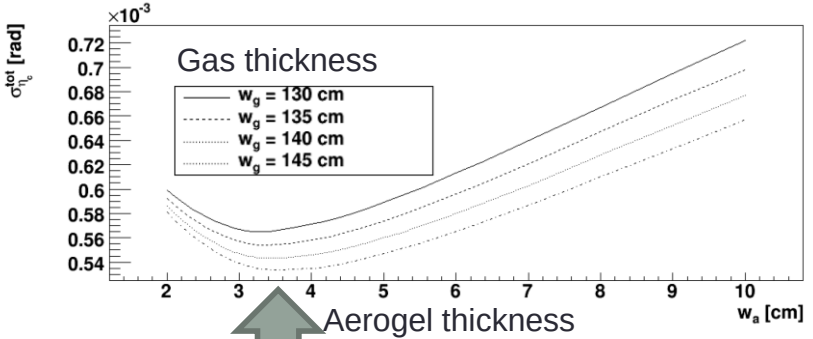
Work done by Alessio Deldotto (INFN)

Systematic conceptual study started

- Optimization for the approximate focusing dual radiator RICH analytically
- Aerogel radiator part, estimation considering
  - Chromatic
  - Emission point uncertainty
  - Pixel-size uncertainty
  - Scattering of light and (UV light filtering)
- Gas radiator part
  - Serve as a threshold device
  - And further use size of the photon blob for differentiation
  - Very challenging for high momentum tracks
- This study now continues for mirror-focused dual radiator RICH



Aerogel ring error VS Aerogel/gas thickness



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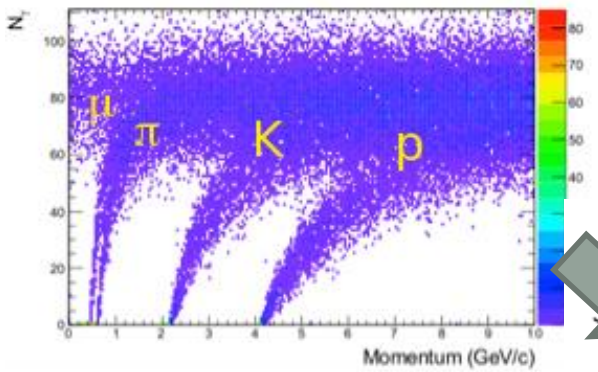
Work done by Liang Xue (GSU), funded under eRD11

Generic purpose analysis packages – Ring recognition

https://github.com/EIC-eRD11



Photons produced in aerogel for mu, pi, K, P

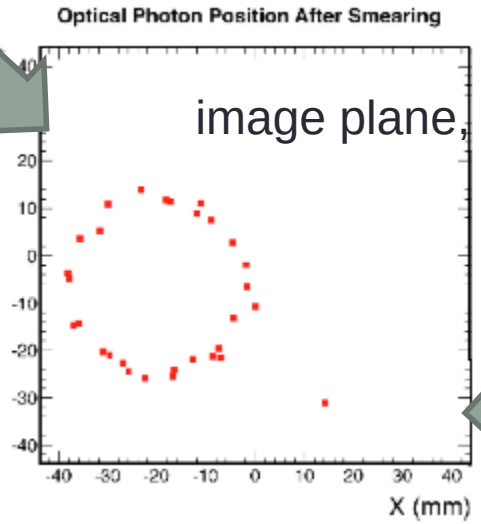
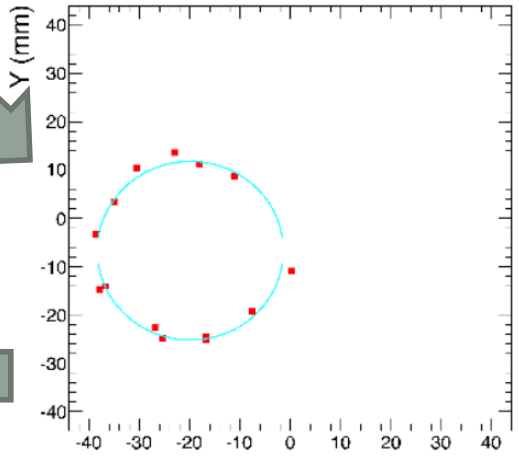
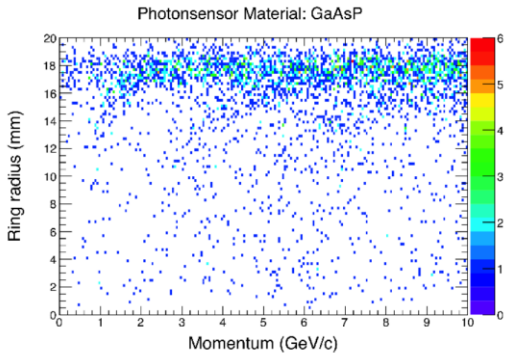


image plane, with resolution smearing

Hough transform based ring finding



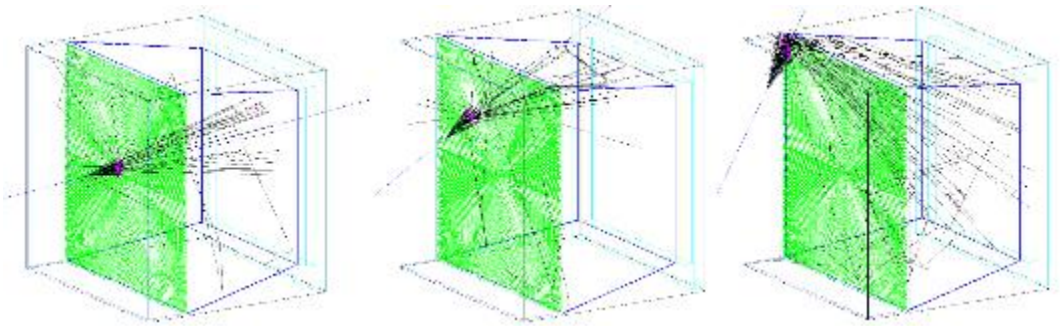
Reconstructed Cherenkov angle VS momentum



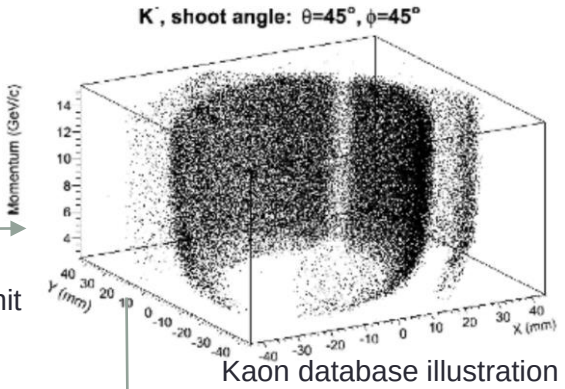
Generic purpose analysis packages – max-likelihood method

https://github.com/EIC-eRD11

Work done by Liang Xue (GSU), funded under eRD11



Generate a database of hit patterns

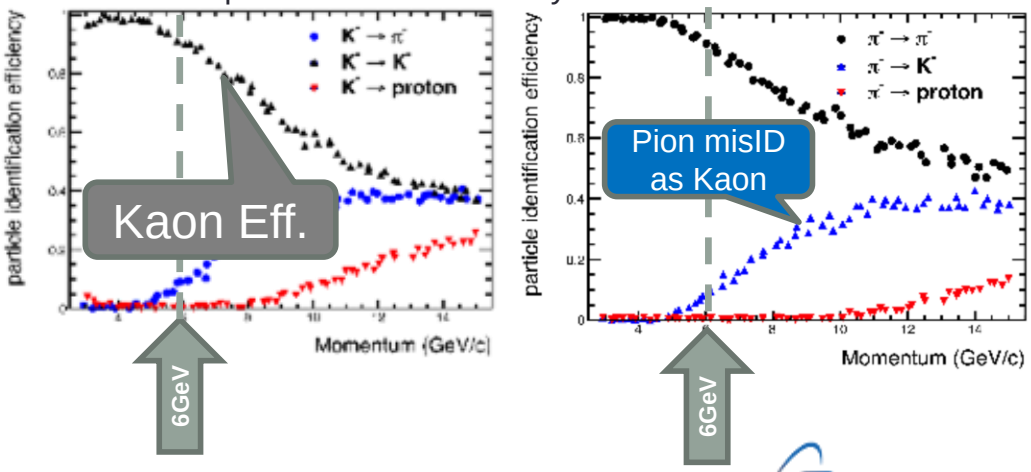


Kaon database illustration

Use this to identify pi, K, p and determine PID efficiencies

Likelihood matching by comparing an event VS database

Final performance : Efficiency and mis-ID VS momentum



Next:

- Fold into larger environment
  - True momentum, angular distributions, particle ratios
- Optimize:
  - Refractive index
  - Thickness
  - Cutoff wavelength
- Determine:
  - Minimum aerogel quality
  - Multiple refactive indices?
  - Maximum pixel size

Hubert van Hecke LANL

More plot in our progress report

Large Area Picosecond Photon Detector

eRD11 Progress Report – July 2015
Period: January 1 – July 1, 2015

- Focus on LAPPD 28 tests (JLAB)
- Argonne progress can be referenced on ANL web site for DOE review (Feb. 2015)
  - https://anl.app.box.com/s/q0s1fs102oi9vltzsucccy2mpdpey3yd

Rodrigo Mendez*, Rachel Montgomery&,
Yi Qiang#, Beni Zihlmann, Carl Zorn
Jefferson Lab
July 9, 2015

* Universidad Tecnica Federico Santa Maria, Valparaiso, Chile
& INFN, Sezione du Ferrara, Ferrara, Italy
# Toshiba Medical Research Institute USA, Vernon Hills, IL

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Recent Review at ANL for LAPPD Project

Public Domain Presentations: LAPPD Review – Feb. 2015

1) Tube Performance Optimization – Jingbo Wang
2) Testing of 6 cm Photodetectors – Jingbo Wang
3) ALD on MCPs: Progress and Status – Anil Mane et al.
4) Argonne R&D Program: Photocathode Development – Junqi Xie
5) Argonne R&D program: New Directions in ALD Coatings for MCPs – Jeffrey Elam
6) Argonne R&D program: Technical Work to build a new Photodetector Facility – Lei Xia
7) Photocathode Development for 6 cm Photodetectors – Junqi Xie
8) Production of 6 cm Photodetector in Small Tile Processing System: - Lei Xia

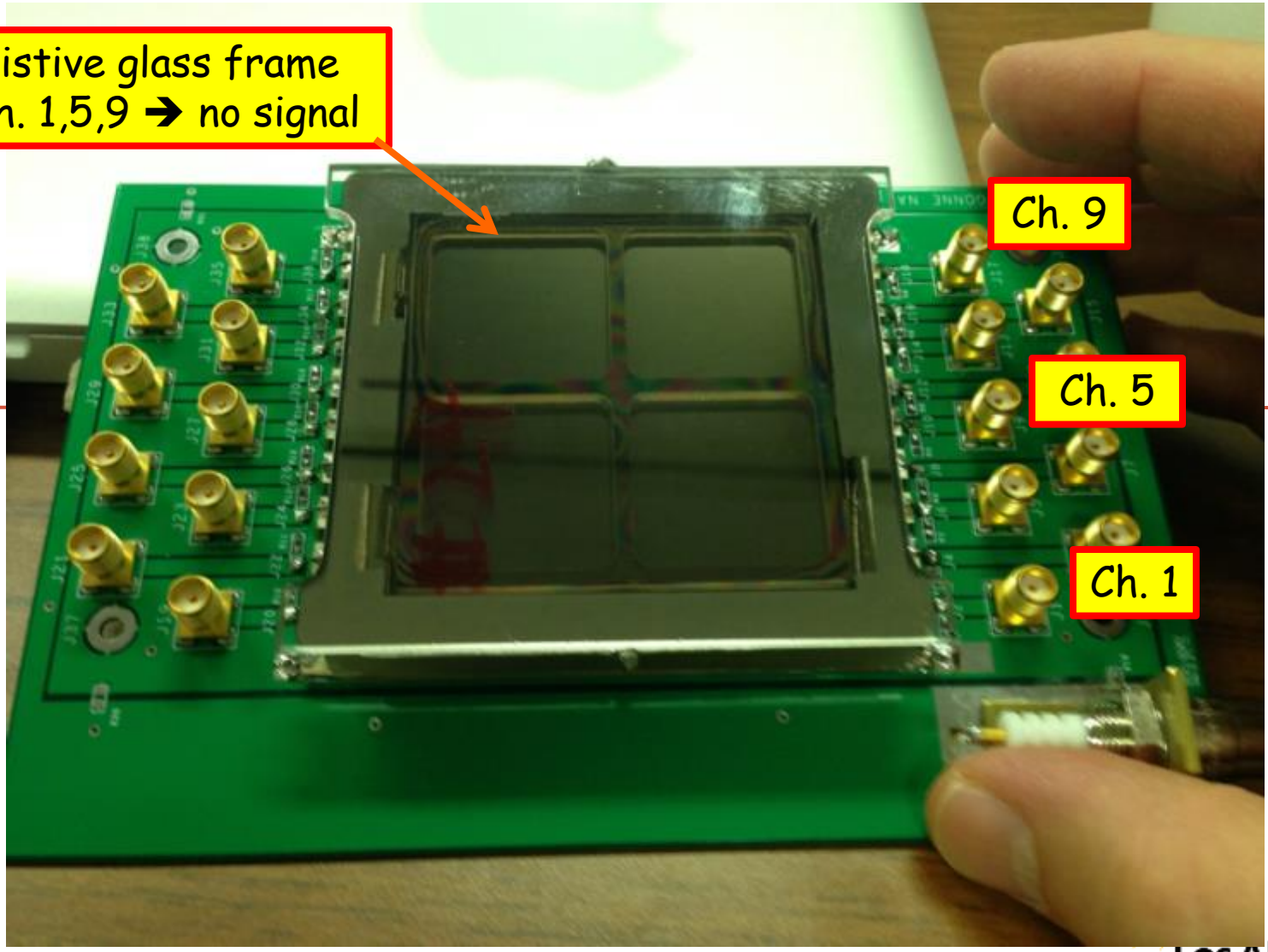
Available for download at https://anl.app.box.com/s/q0s1fs102oi9vltzsucccy2mpdpey3yd

Preparation for high B field Tests
January – July 2015

- *Proceed with preparation for high B field tests using VME DAQ (QDC)*
  - Place sample in mobile non-magnetic dark box mounted on aluminum rail
  - Allows for both linear motion in B field and horizontal rotation
  - Feed in UV (370 nm) pulses light via fiber optic
  - Diffuse light from fiber optic to uniformly illuminate LAPPD
  - Attempt to get single photoelectron spectra (SPE) by actively blocking adjacent readout channels – this worked well with standard MCP-PMTs such as Photonis Planacon
  - Get mobile test station (DAQ and PC laptop) ready
  - If new sample arrives, switch out with original and characterize it – otherwise proceed with current one (#28)
- ***Test Location: Intent is to use 3T MRI at nearby UVA Medical School → 2 hr drive west of JLAB in Charlottesville, VA***
  - ***Backup solution – Argonne in 2nd half of August***
- Future - follow with neutron radiation hardness test – no facility chosen

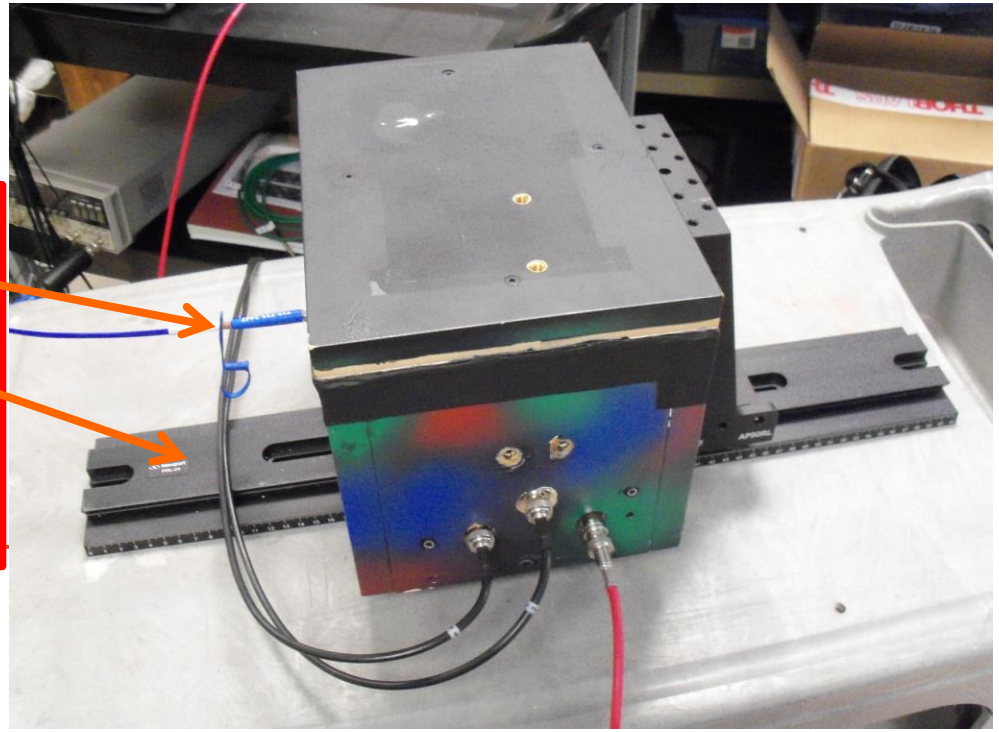
11 strips – 9 instrumented – 2 outputs/strip
Strips: 85.3 mm (L) x 4.72 mm (W) x 2.34 mm (interval)

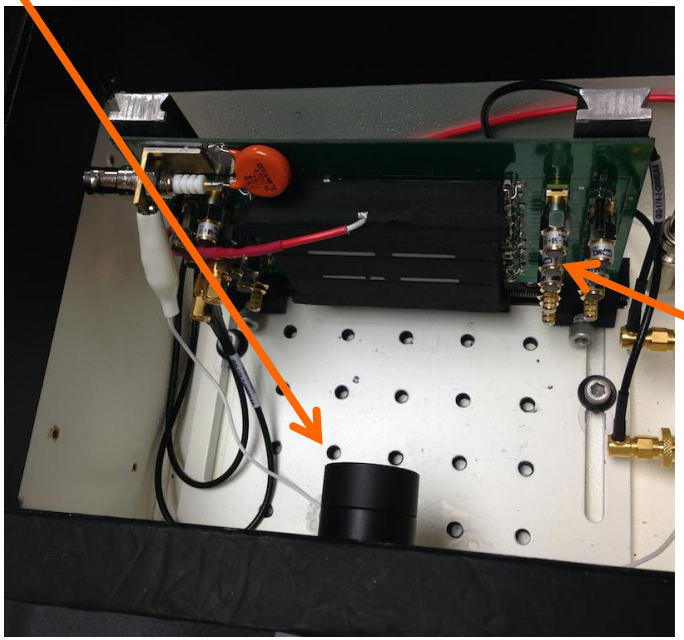
Resistive glass frame
➔ Ch. 1,5,9 ➔ no signal



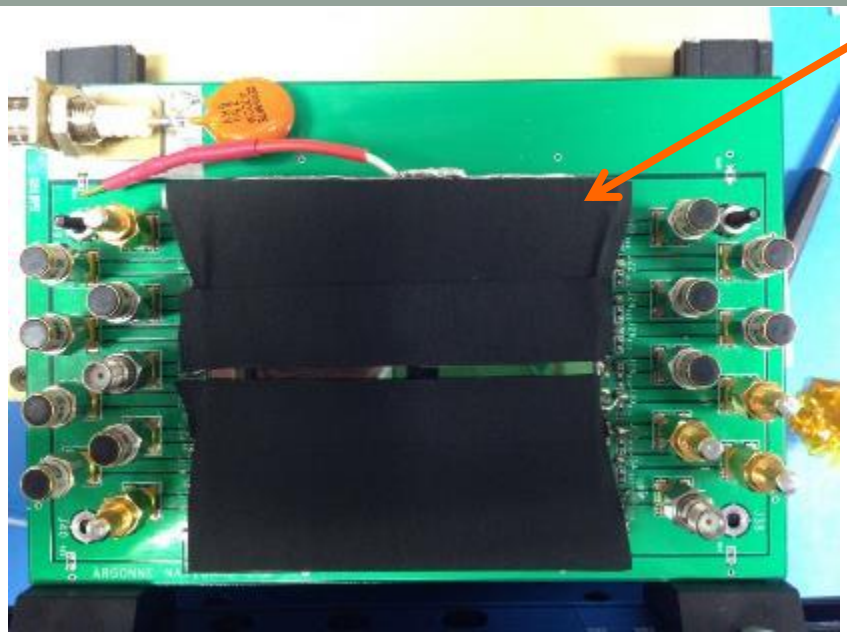
Mount detector in mini dark box for B field testing

- Use only non-magnetic components
- Fiber optic brings in pulsed UV light (370 nm)
- Mount on rail for insertion into B field
- Allows both linear and rotational motion
- Diffuser inside box illuminates surface uniformly



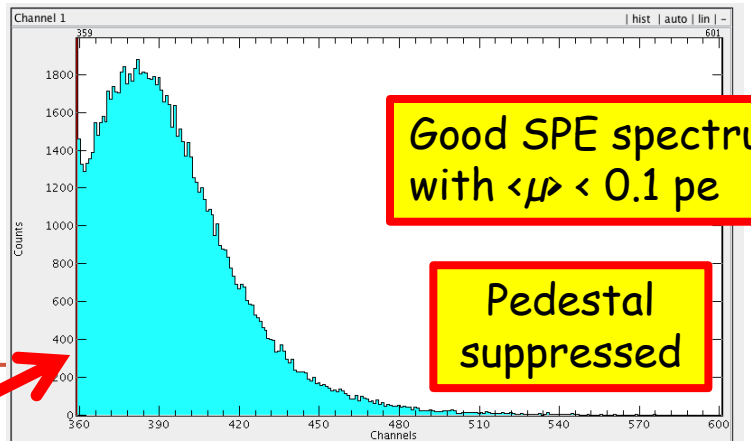


Box Interior
Sample with adjacent readout channels blocked
(Ch. 3 and 6 will be readout)



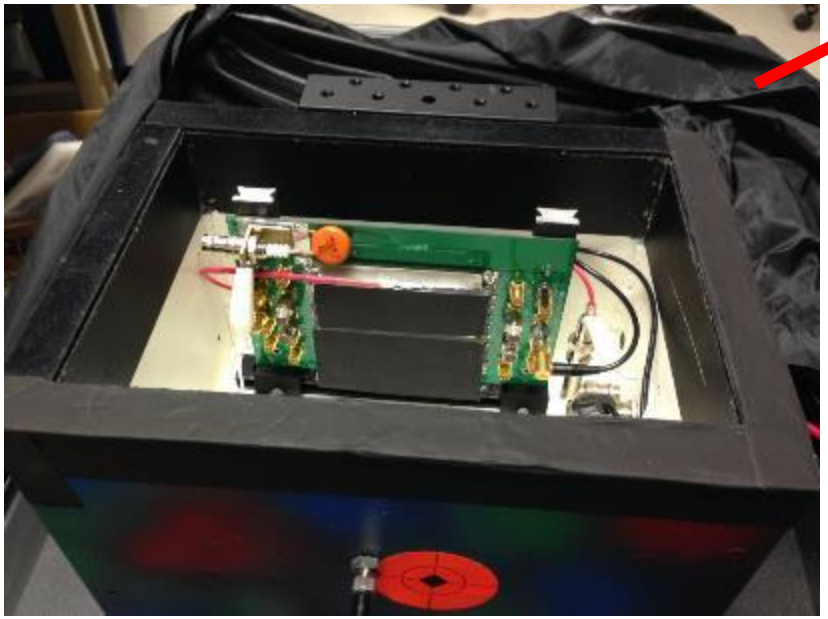
Tape has > 10^5 attenuation

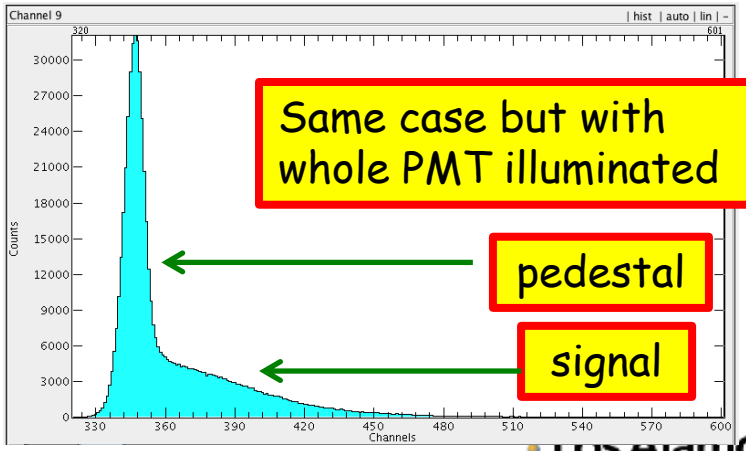
Block all but 3 mm wide strip centered on a readout "pixel"



Good SPE spectrum with $\langle\mu\rangle$ < 0.1 pe

Pedestal suppressed

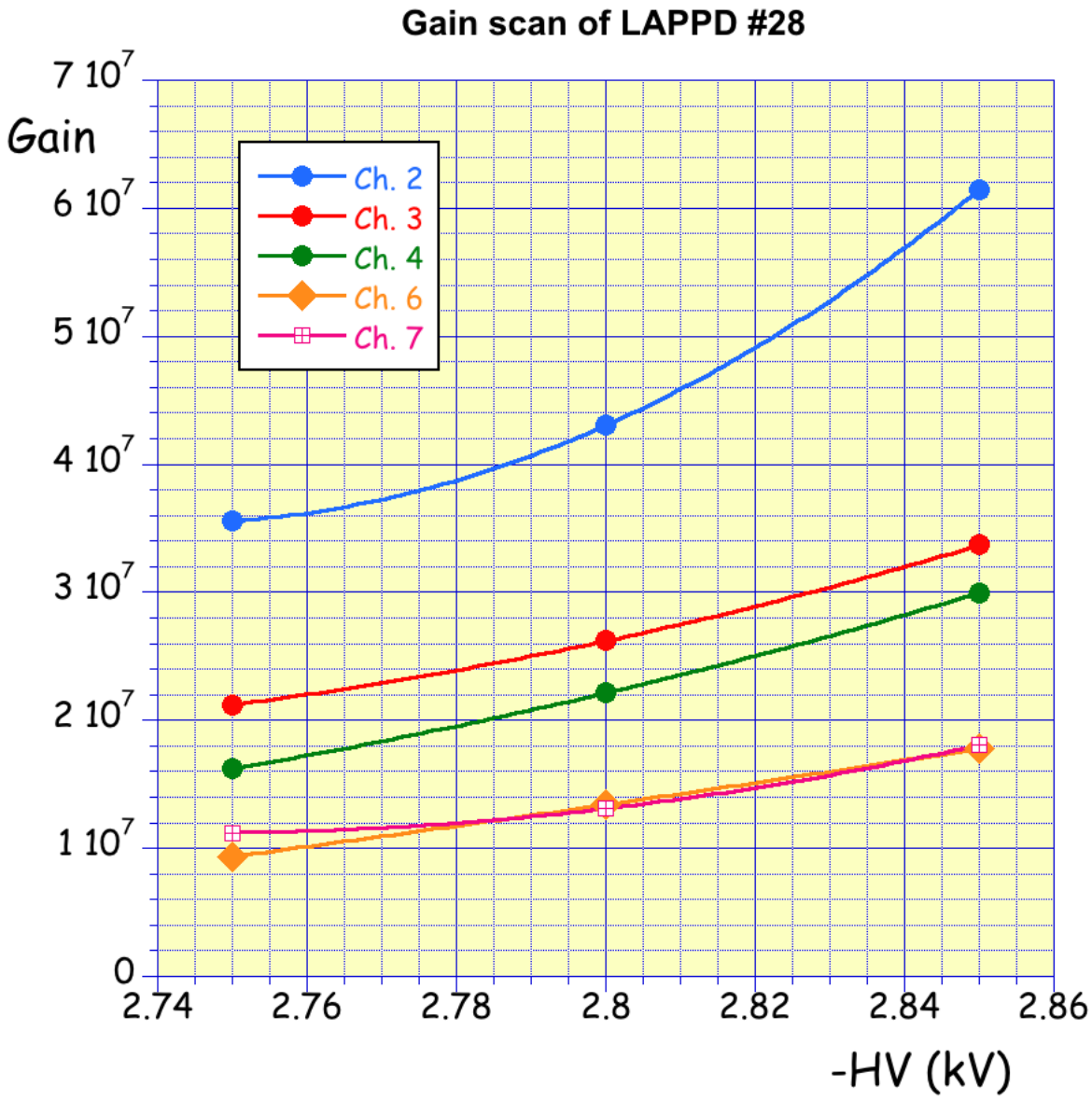




Same case but with whole PMT illuminated

pedestal

signal



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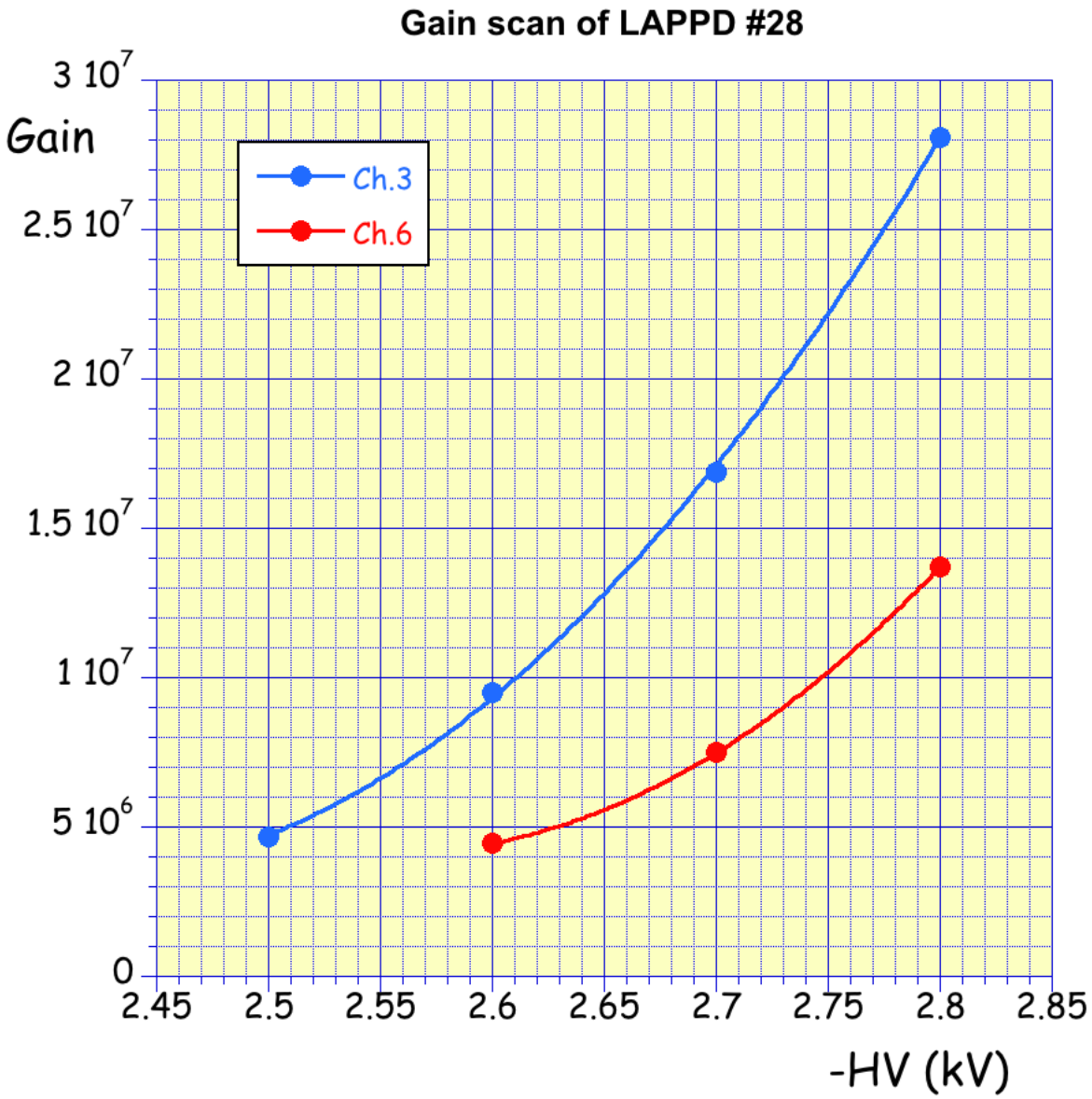
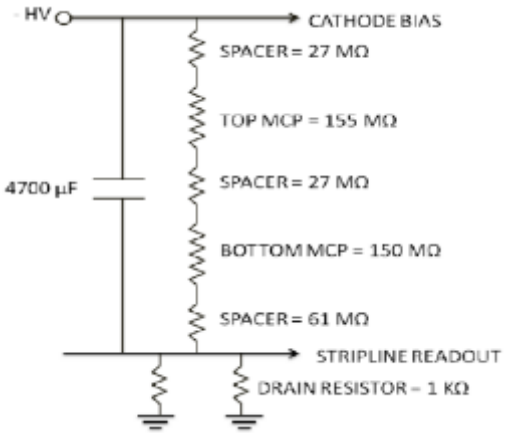
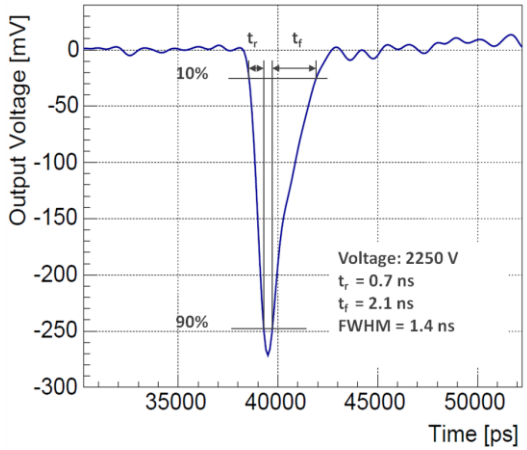


Next Steps in Improvement from ANL

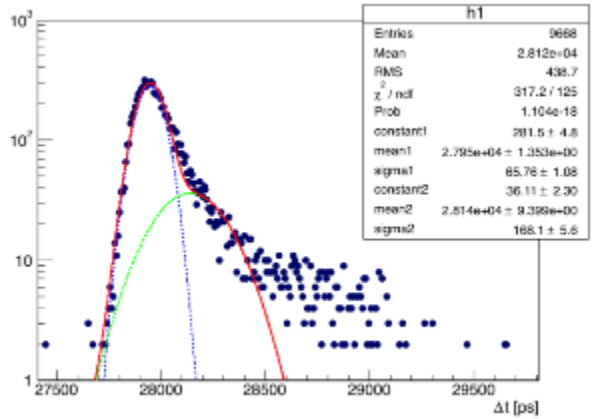
(1) Resistor HV chain design



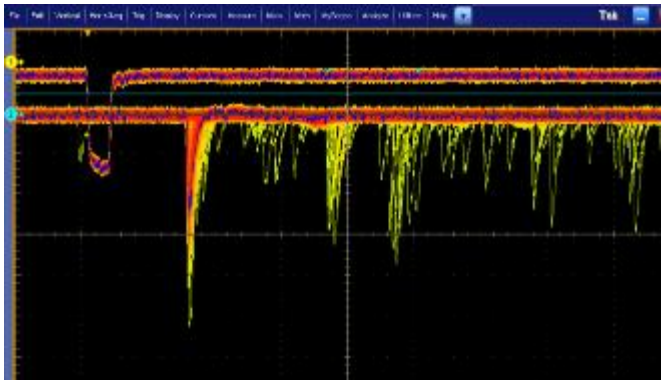
(2) Rise time



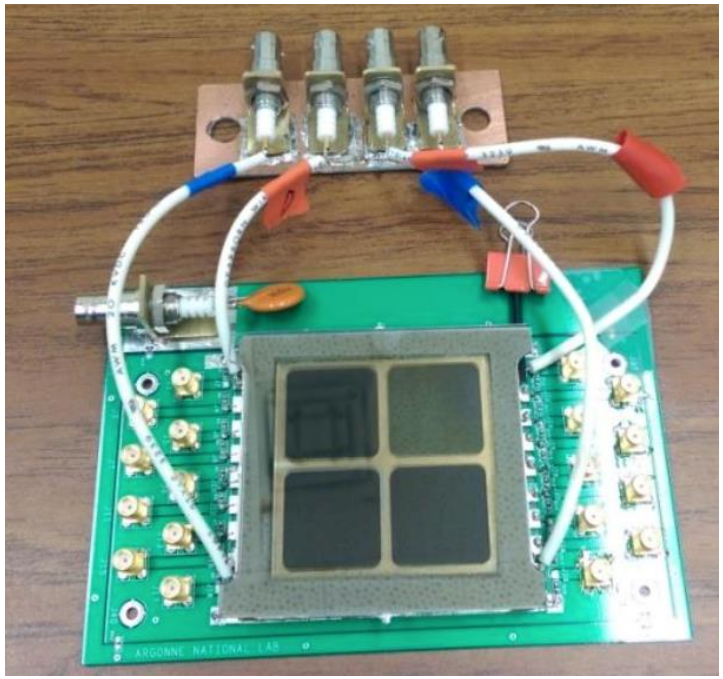
(3) Timing distribution



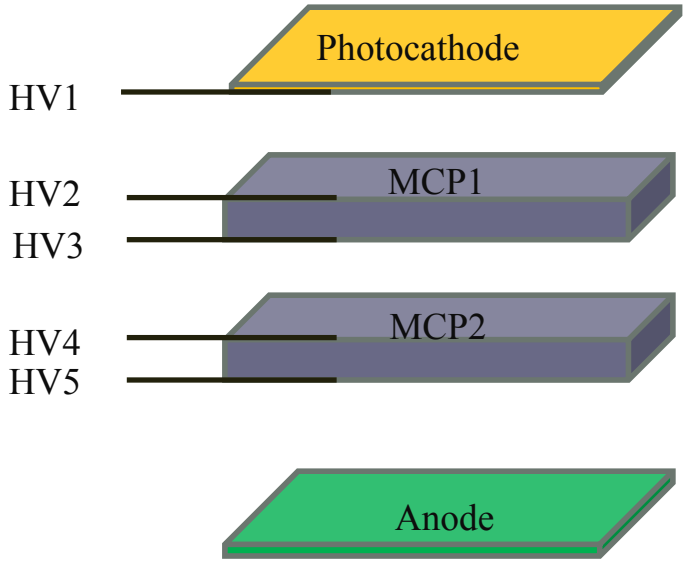
(4) After pulsing reduction



Next Samples – Individual Bias Adjustments



Individual bias design



Benefits from a new design

- Direct measurement of QE
- HV optimization
- Allow for monitoring of all components
- Lifetime test
- Study on MCP working principle

Next Samples – Data Sheets

Argonne NATIONAL LABORATORY

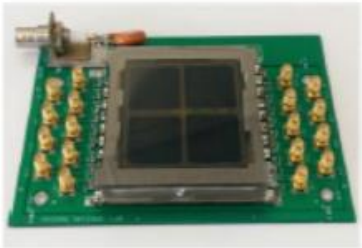
High Energy Physics Division

6cm x 6cm Photodetector Data Sheet

Photodetector Tube No.: # 32
Mfg Date: Oct. 15, 2014

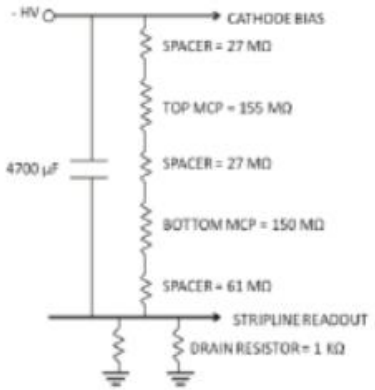
SECTION 1: DESCRIPTION

Window material	Borosilicate glass
Window mask	NiCr
Photocathode type	Bialkali
Multiplier structure	MCP chevron (2), 20 μm pore, 60:1 L:D ratio
Stack structure	Resistor chain design
Anode structure	0.47 cm sliver strip line, 0.23 cm space
Active area	6 cm x 6 cm
Package open-area-ratio	65 %



SECTION 2: CHARACTERISTICS

Photocathode Characteristic	
Spectra response range	300 nm ~ 600 nm
Quantum efficiency	Max: 20%
Timing Characteristic	
Operation voltage	2100 V - 2600 V
Transition speed	1.8 mm/ns
Gain	1e6 - 1e7
Single Photoelectron	
Time resolution	57 ps
Position resolution	/
Multi Photoelectron	
Time resolution	15 ps
Position resolution	<0.5 mm



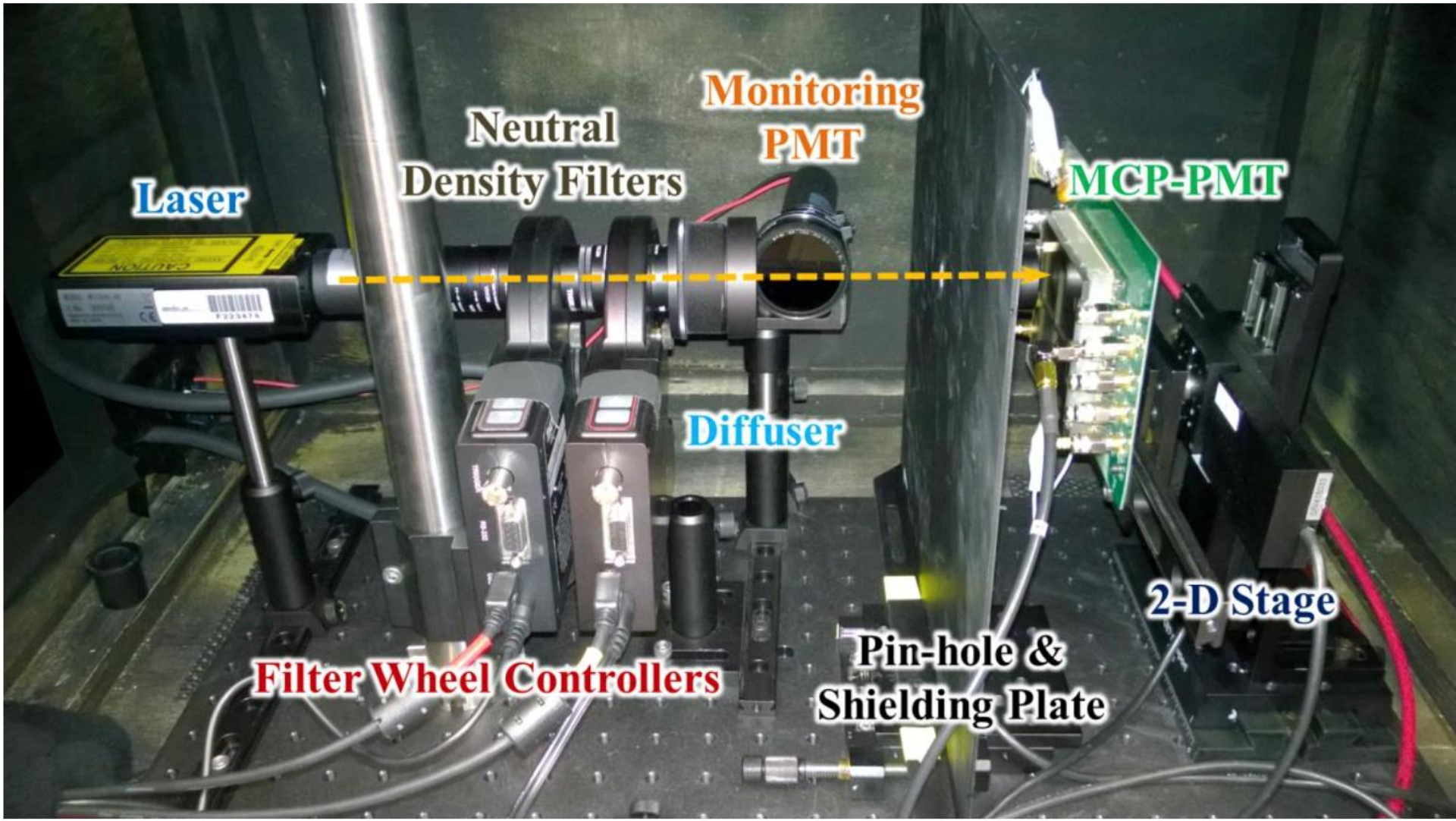
Backup Slides

Summary from January, 2015

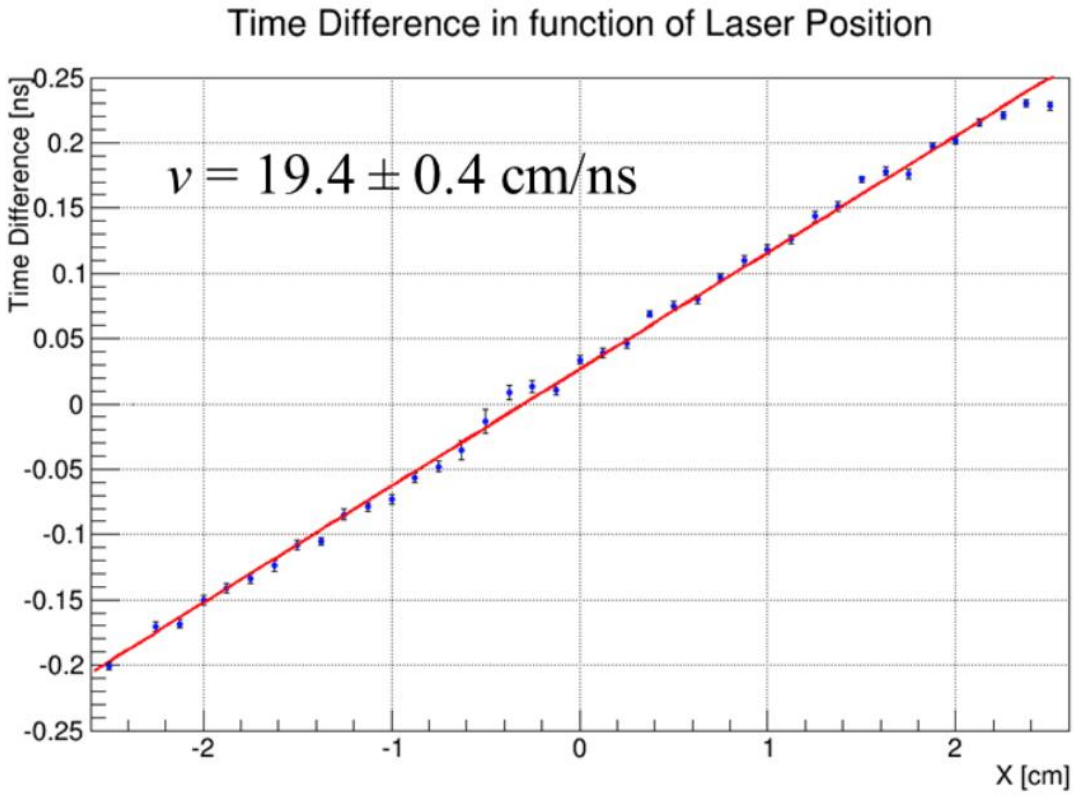
Lab Tests of the LAPPD sample 28 (using Oscope DAQ)

- Initial use of setup similar to ANL – pulsed fast blue laser – had to diffuse light and use collimation to get small beam spot (2 mm) – LAPPD moved on 2D stage behind the 2 mm hole 1
- Able to use timing difference to plot position across a readout channel 2
- Measured width of readout channel and signal non-uniformity across a channel 3-4
- Could not obtain good single photoelectron spectrum (SPE) – used alternate estimation method 5-7
- Used this estimate to check gain uniformity across a strip and among the strips 8
- Also estimated PDE by comparing "SPE" of LAPPD with good reference PMT
  - LAPPD PDE ~ 2%
- Comparison with gain estimates indicates photocathode non-uniformity
- Two factors probably contribute to lack of good SPE
  - Resistive elements inside LAPPD changed their resistance
  - Higher than expected ambient light levels may have lead to charge sharing among readout channels *contaminating* SPE spectrum

JLAB Test Setup



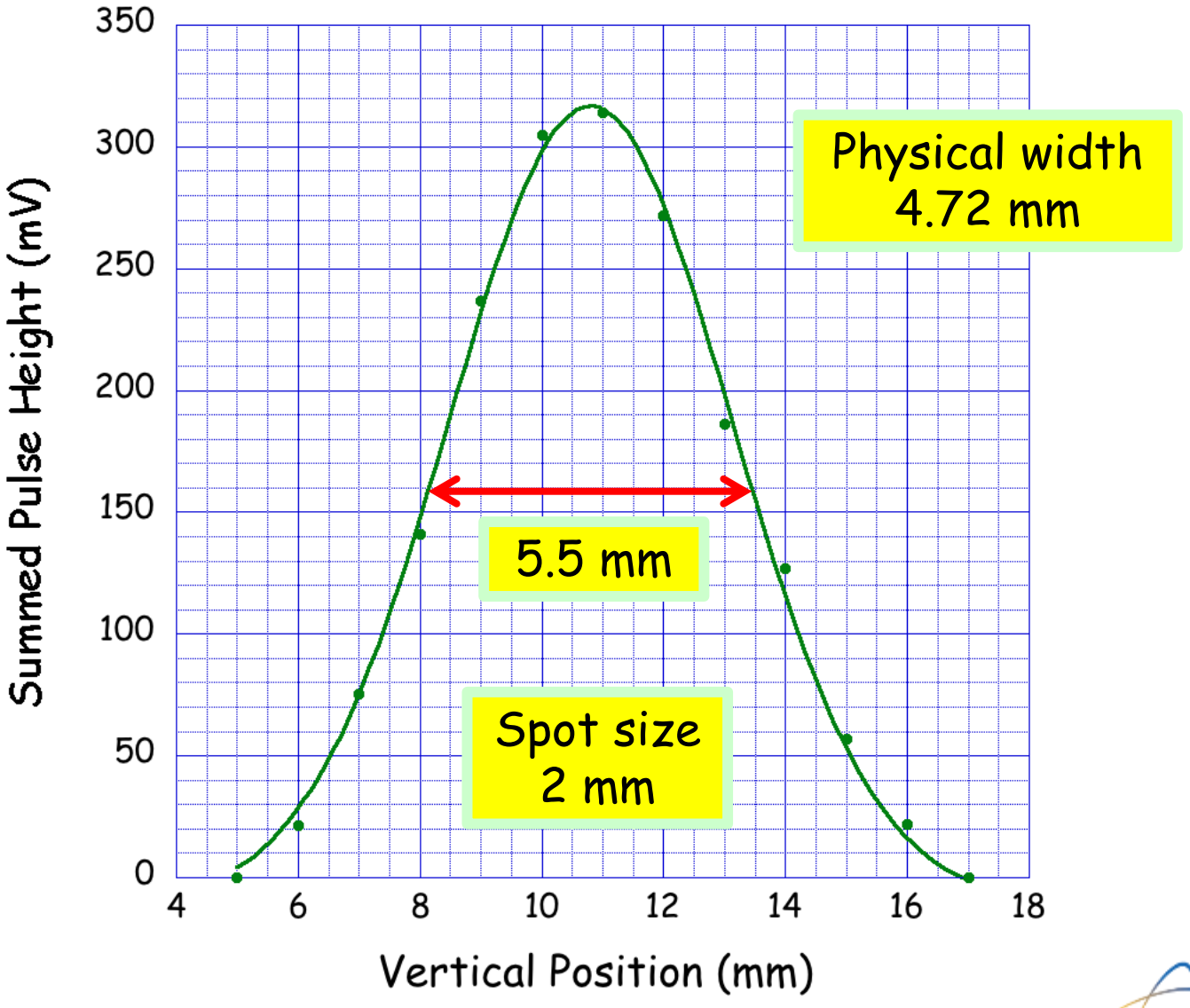
Signal Strip Transmission Speed (JLAB)



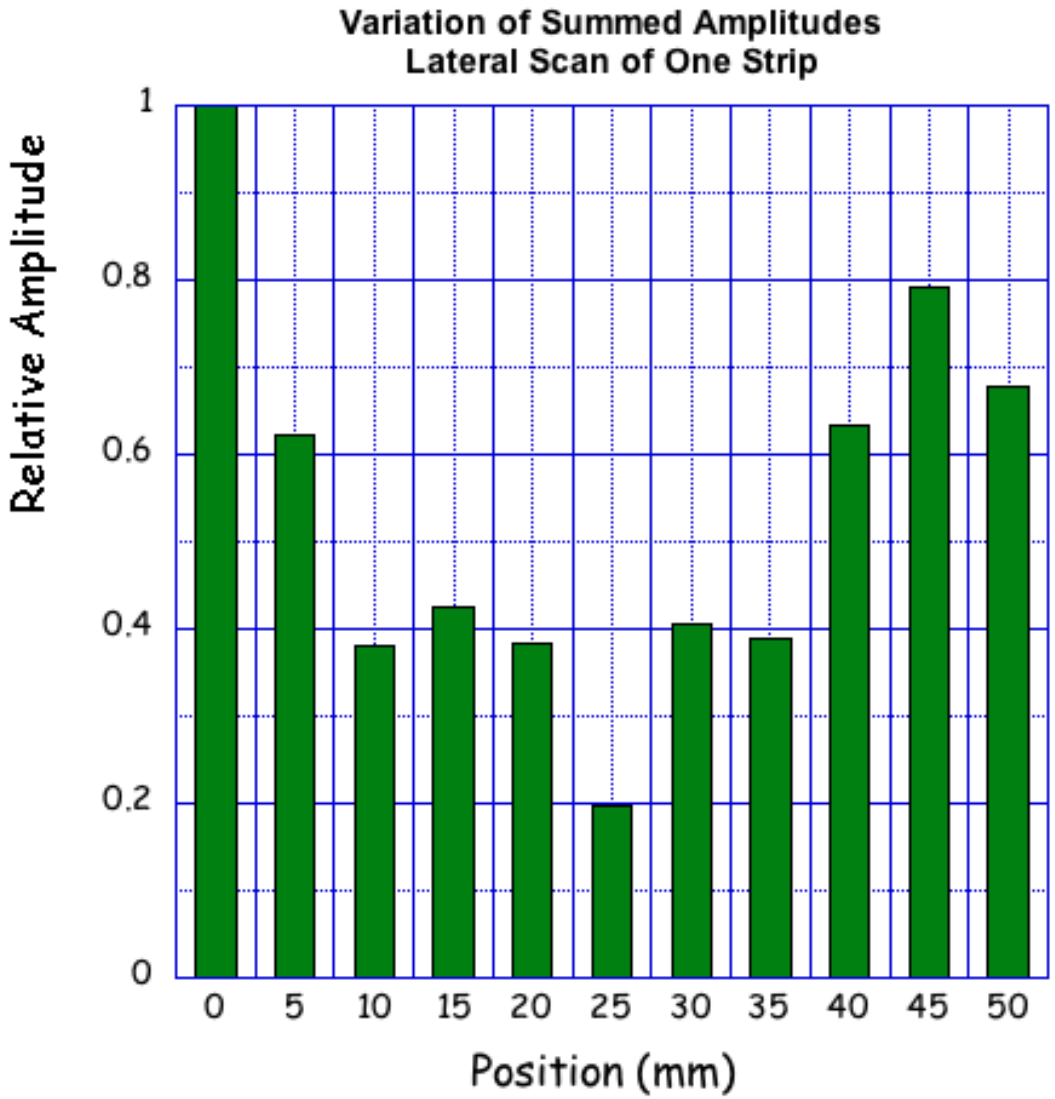
Measured at single photoelectron level

Strip Signal transmission speed
178 μm/ps (ANL)
194 μm/ps (JLAB)

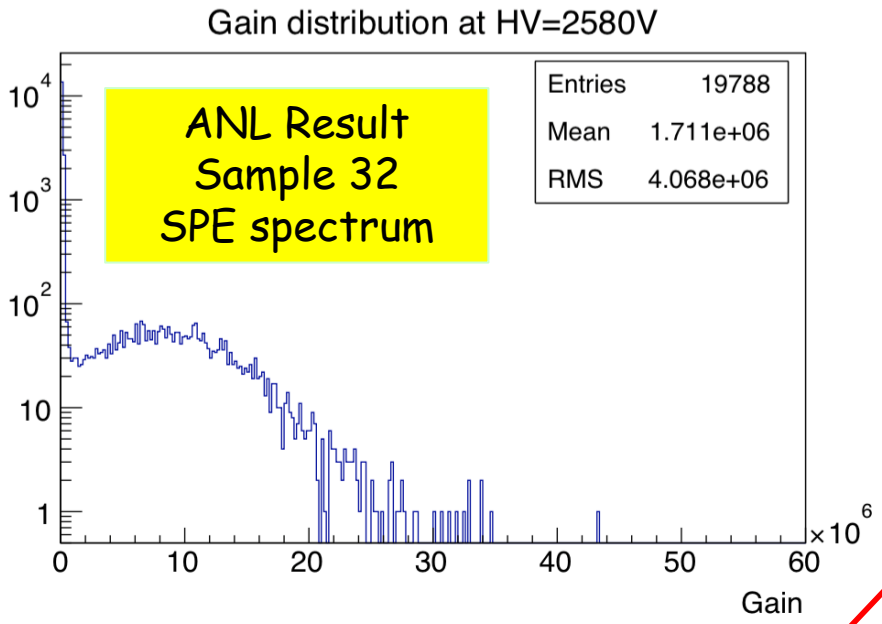
Vertical scan across one readout strip

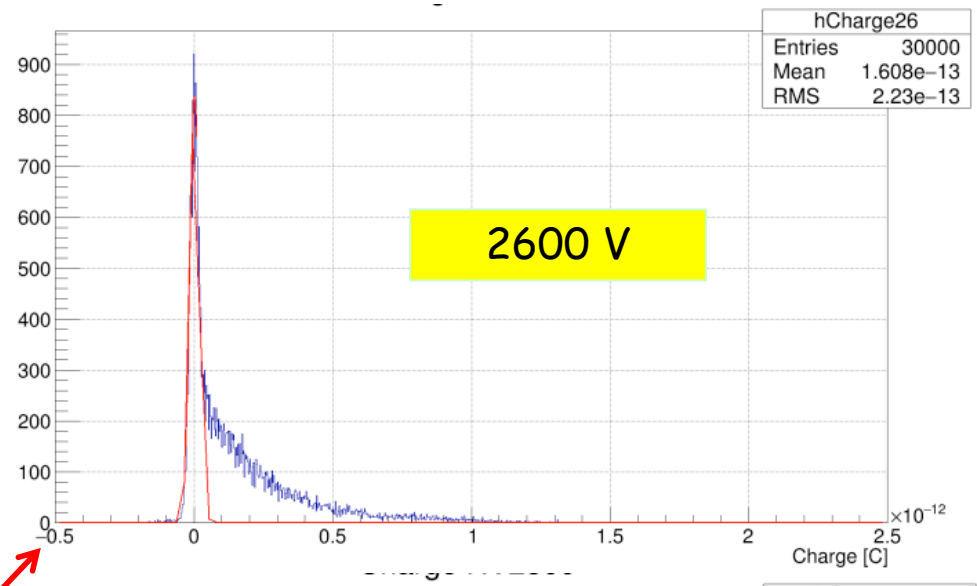


Amplitude variation (horizontal) across one readout strip

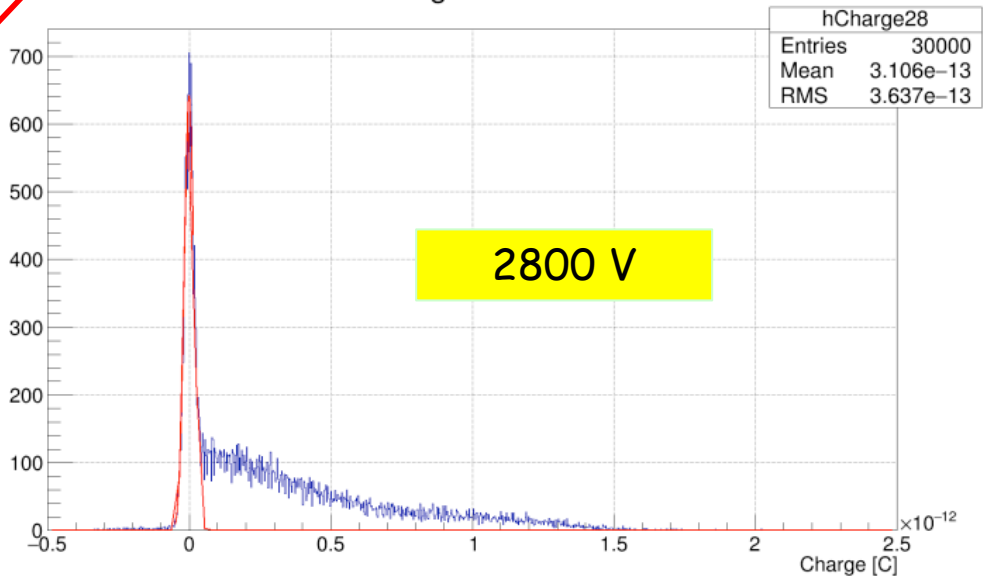


Gain Estimates from SPE-like spectra

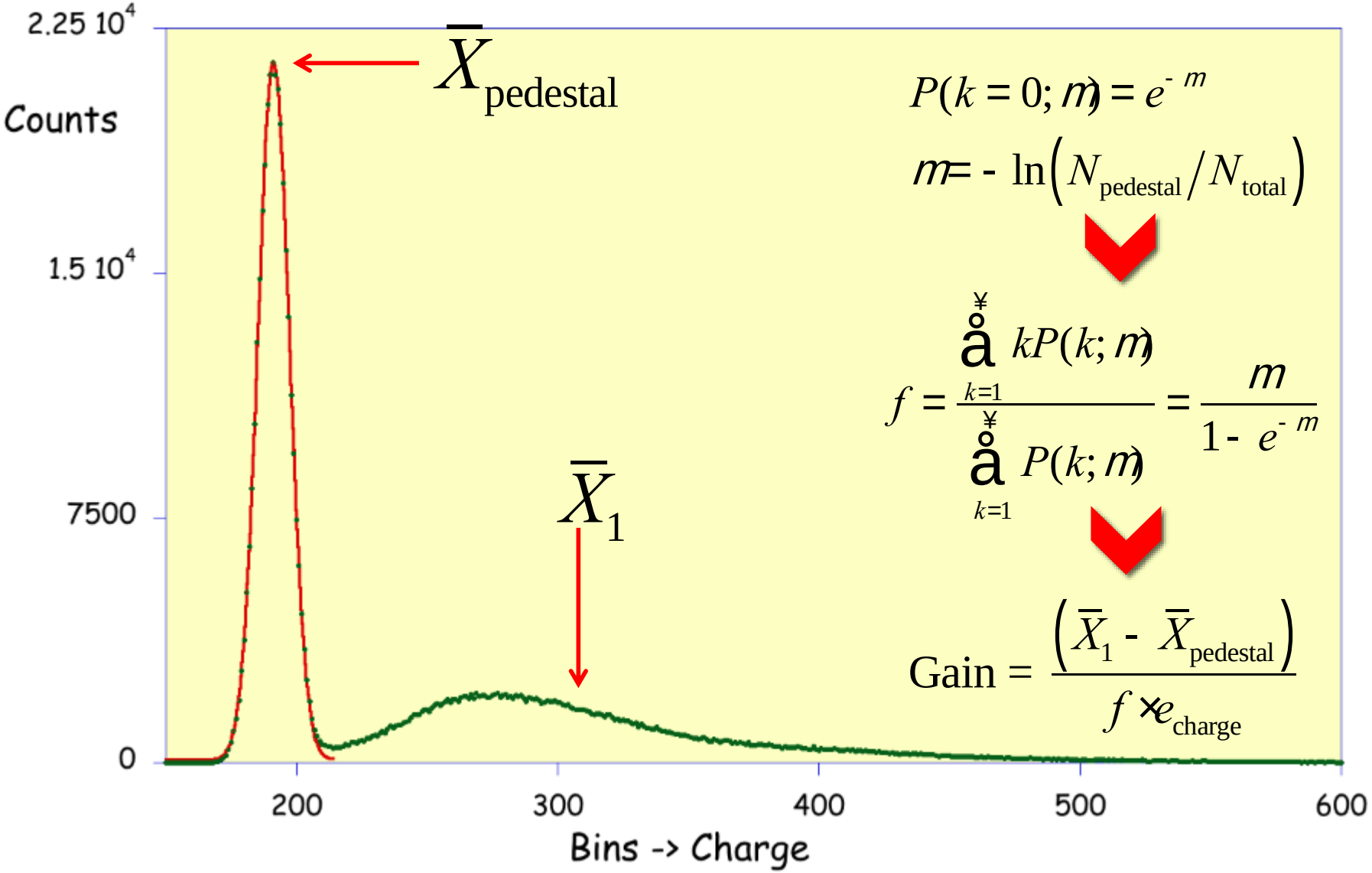




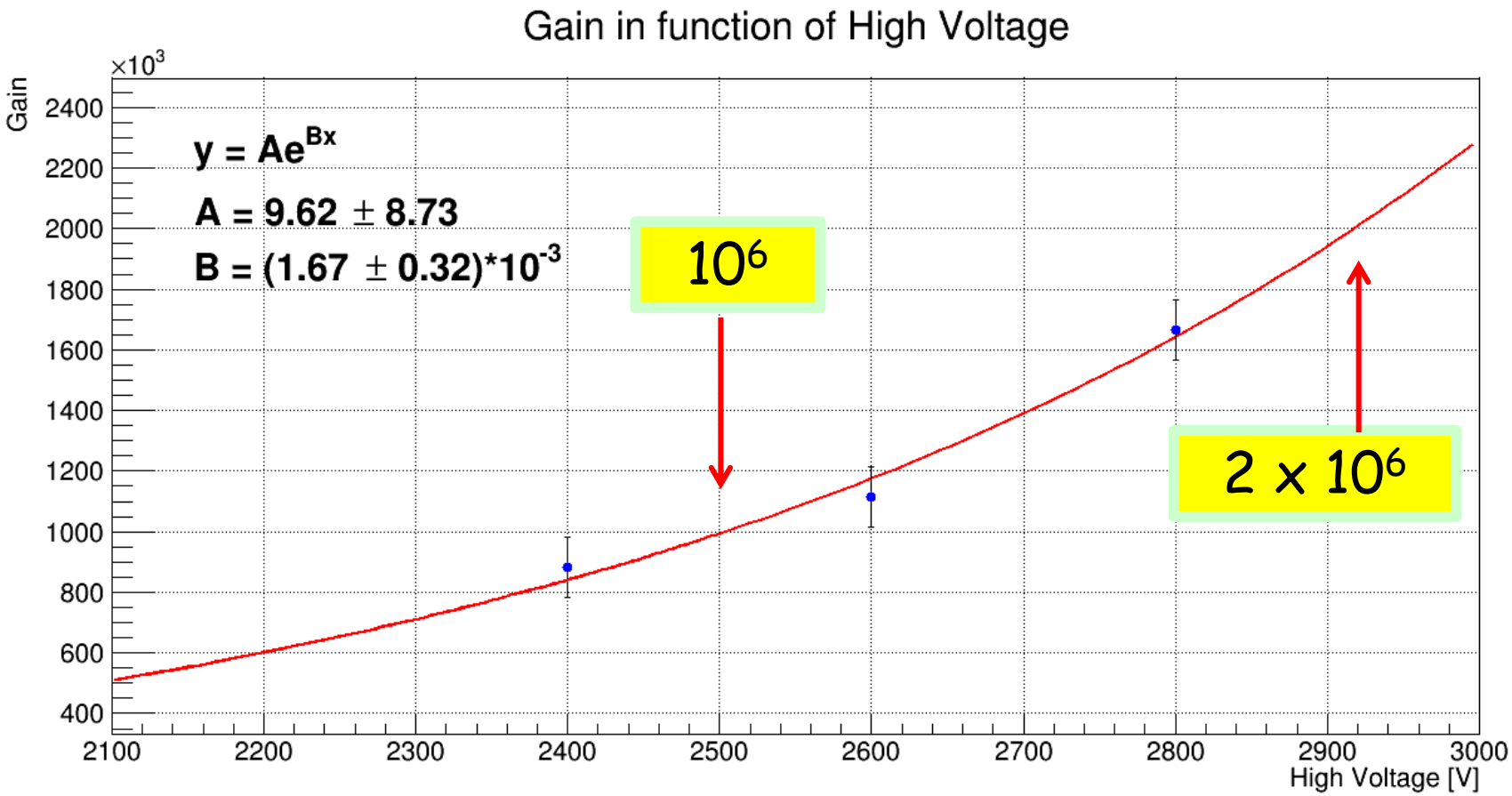
JLAB Results
Sample 28
Poor SPE resolution



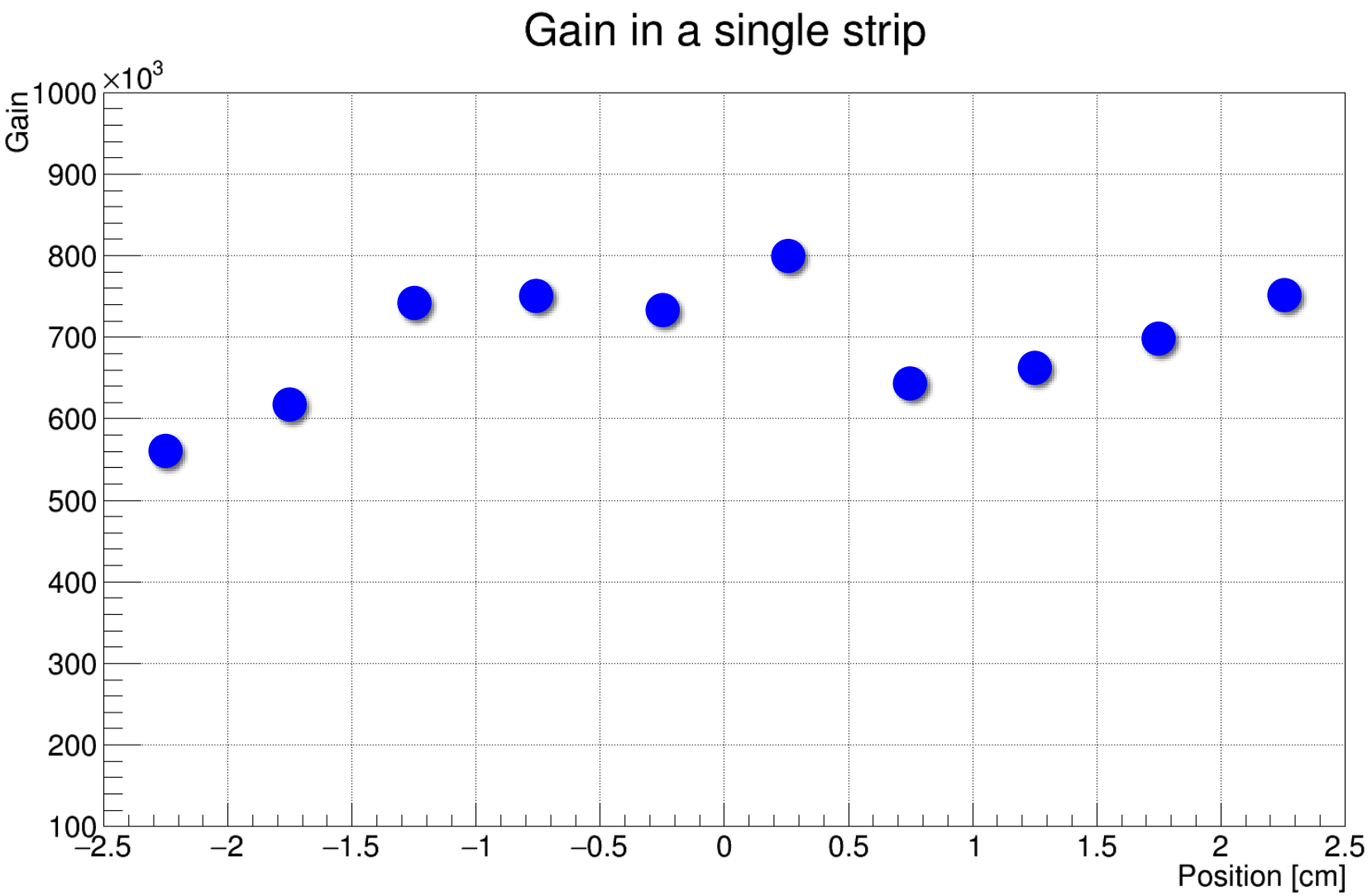
Yi Qiang - Estimating the Gain with Poisson Stats



Gain Estimates from SPE-like spectra



Estimated Gain across (length) one readout strip



LAPPD pulses (2 ch.) from 370 nm UV LED

Backup 9

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